POLICY BRIEF

Institute for Policy Research

UNIVERSITY OF BATH

Hydrogen storage materials: driving developments in transport and smoothing routes to renewable generation

About this research

Hydrogen is a sustainable, non-polluting and low carbon alternative to fossil fuels; its use can reduce the negative effects of climate change. However, whilst there is public concern over climate change and support for the use of renewable energy sources, there is also distrust of using hydrogen as a fuel. New and safer methods for storing hydrogen are needed for transportation systems. In addition, generating and storing hydrogen at times when there is excess energy production capacity on the electricity grid can help balance the variability of demand and prevent wastage of surplus energy.

This brief outlines research programmes within the University of Bath's Department of Chemical Engineering, focused on the development and evaluation of new materials for safe hydrogen storage for use in transport and grid systems. In particular, it highlights the work of University Prize Fellow Dr Valeska Ting.

Research findings in context

Combustion of fossil fuel is the primary method of driving transportation systems today. Yet these fuels are a limited resource, with estimates of global reserves standing at around 50 years. Alternative fuel sources must be adopted if we are to maintain our current lifestyles.
Hydrogen can be used as a sustainable alternative to fossil fuels, but currently it must be stored as a compressed gas at high pressures or a liquid at extremely low temperatures. There are public concerns about the safety and energy efficiency of such storage methods.

As an alternative storage method, adsorption of hydrogen into porous materials (such as zeolites, activated carbons and metal-organic frameworks) means hydrogen can be stored at very high densities, hence greater amounts can be conveniently stored in smaller volumes at temperatures and pressures closer to ambient conditions. Adsorption is a surface effect, so developing novel porous materials with high internal surface areas is an important aspect of this research. Structural modification of existing porous framework materials to increase their internal surface areas is predicted to triple the hydrogen storage capacity under safer, low pressure storage conditions. The resulting materials are also expected to have greater mechanical strength, improved resistance to degradation, faster heat conduction and better electrical conductivity, enabling the storage materials to be turned into practical on-board hydrogen fuel cell energy systems. Companies that are involved in the manufacture of commercial metal-organic framework materials (such as BASF and MOF Technologies Ltd) could benefit from adopting new synthesis routes to produce more active materials. In addition, the incorporation of carbon nanomaterials can lead to increased shelf life and simpler storage conditions, resulting in cost savings for these companies.

These new materials will, in turn, feed into the transportation sector, being taken up by companies that have interests in using hydrogen as a replacement for fossil fuels over the next 10-50 years. These companies include aviation and aerospace companies, such as EADS/Airbus, and vehicle manufacturers such as Ford, Jaguar/Land Rover and BMW. The development of new materials with higher storage capacity at safer low pressures would allow these companies to develop more competitively-priced, industry-leading prototype hydrogen-fuelled vehicles. Providing other beneficial physical properties such as improved mechanical strength, thermal or electrical conductivity makes these materials even more useful and would encourage design of multifunctional systems for efficient integrated energy storage and delivery.

Key applications

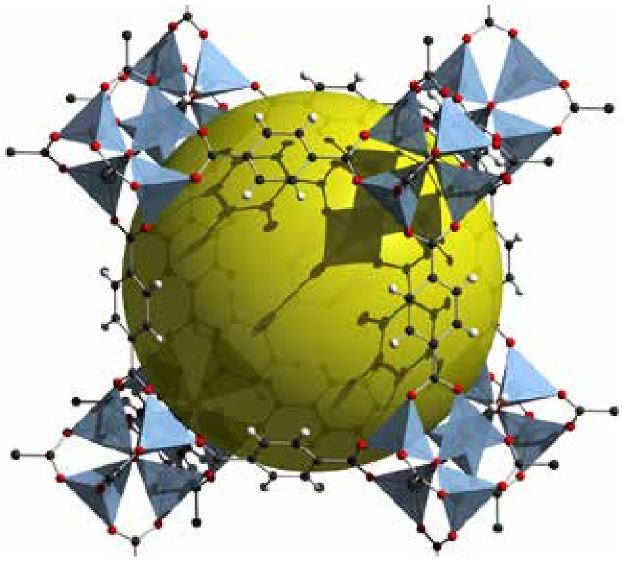
- Research into gas storage materials has positive impacts on the economy, by opening up new manufacturing and engineering opportunities, as well as enhancing health via improved air quality and helping prevent environmental damage.

- Development of efficient hydrogen storage will allow effective management of the energy produced from intermittent renewable sources such as wind and solar power, increasing the penetration of renewably-generated energy into the national grid.

- Aviation and aerospace companies, as well as automobile manufacturers, will be able to develop more competitively-priced, industry-leading transport systems.

- New employment opportunities can be developed within the UK, based on emerging hydrogen technologies, including in transportation and grid-energy storage.

- Quality of life can be improved through reduced air pollution from fossil fuel combustion and lower energy prices through less wastage of surplus generated energy.



Such novel materials would have other valuable and practical applications to environmental and manufacturing challenges, for example in locking up CO_2, in catalysis and in wastewater treatment.

A second important aspect of this research is the development of new experimental methods for examining and evaluating porous hydrogen storage materials. This research will allow more accurate evaluation of the hydrogen storage capacities and determination of the best storage pressures and temperatures to maximize this capacity. The development of these new techniques will enhance our research capabilities and will place the UK at the forefront of global research into porous hydrogen storage.

Policy implications

Developing materials for safer hydrogen storage can overcome negative public perceptions of the risks of new technology, opening up the possibilities of clean, efficient transport systems.

It also results in significant economic gains for the UK in the form of new manufacturing businesses and new employment opportunities in these emerging hydrogen technologies.

Hydrogen storage can facilitate the implementation of renewable energy generation on the national grid - for example, since 2011 in the UK alone, approximately 185 gigawatt hours of surplus electricity (enough to provide 56,000 homes with electricity for a year) was generated from wind turbines during periods of low demand and could not be used or stored. This excess energy could be converted into hydrogen, which, with the provision of safe and efficient storage methods, could be used to drive domestic transport or even exported to other countries as a fuel, generating further income for the UK economy.

More efficient power use through hydrogen storage technology would impact directly on the quality of life of UK citizens through reduced air pollution (as fossil fuels are displaced by clean-burning hydrogen) and lower energy prices (as the energy generated can be stored more efficiently, leading to lower base power levels).

Brief methodology

The research will develop new materials through assembly from the molecular level upwards, as well as focusing on developing a better understanding of which design parameters have the most significant effects on the material's functionality. This enables the research to extend away from development of simple storage materials towards more integrated hybrid systems which will offer superior heat transfer or electrical properties.

The research programme delivers not only the new materials and information about their physical properties, but also develops the synthetic production methods which can be taken up into industrial production, benefiting the UK economy as well as new methods of analyzing these materials, putting the UK at the cutting edge of scientific research.

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More about this research:

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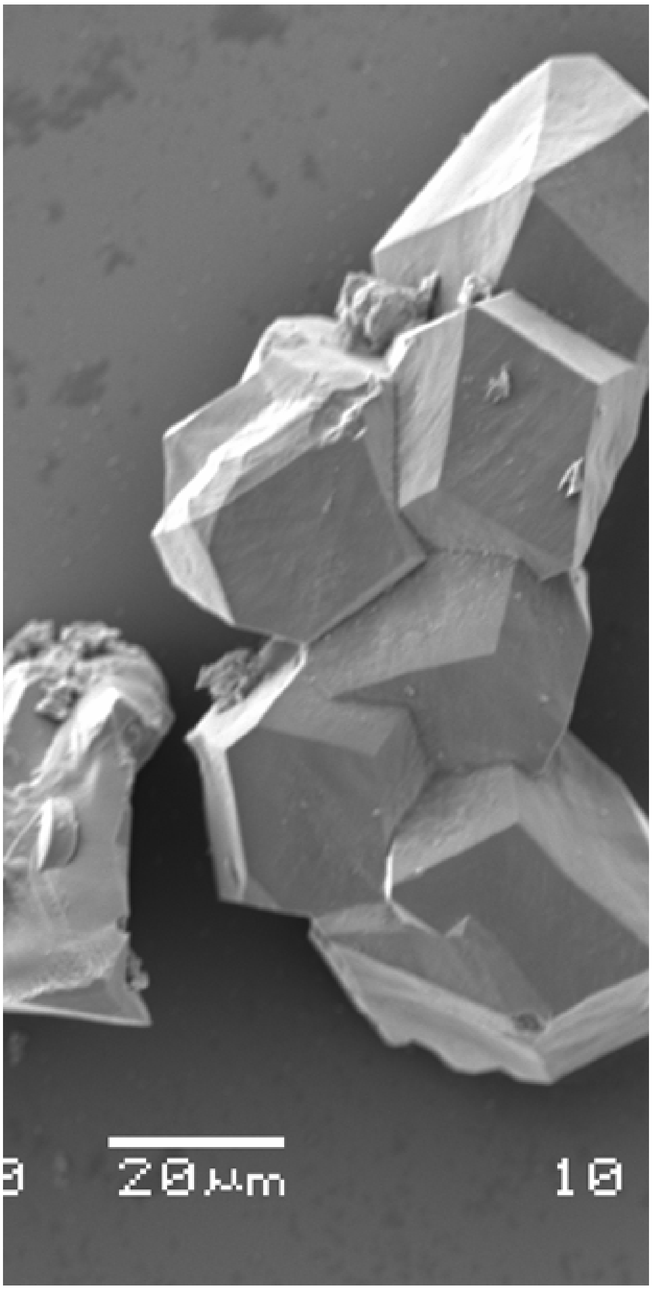

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